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THE INFLUENCE OF ULTRAVIOLET RADIATION ON THE CONTENT AND DESORPTION OF DEUTERIUM FROM CO-DEPOSITED LITHIUM FILMS

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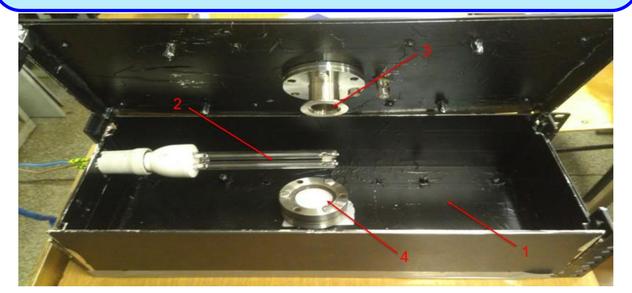
1. Introduction

- Co-deposition is the main channel of tritium accumulation in tokamaks
- Lithium hydride changes color under influence of UV radiation
- It is possible to use UV radiation to detect areas of deposition

2. UV radiation exposure on crystalline lithium hydride

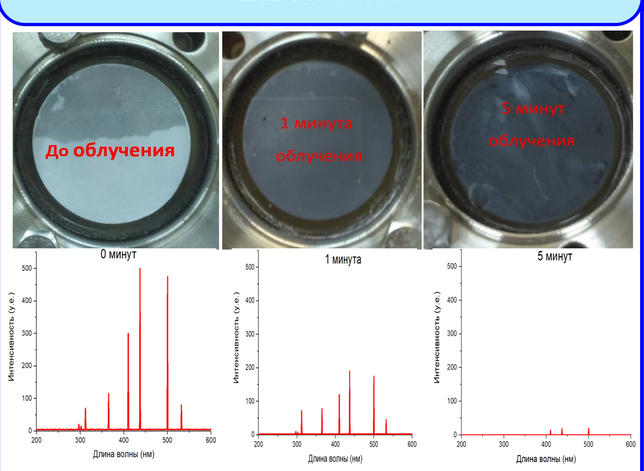
2.1. Description of experiments



1. Light-tight volume
2. Ultraviolet lamp
3. Photosensor input
4. Container with glass from MgF_2

- Irradiation of powder LiH, ~100 μm crystals
- Time of irradiation – from 1 minute to 1 day
- Main light length of irradiation– 180 nm
- The reflectance spectrum was measured with a broad spectrum spectrometer

2.2 Results

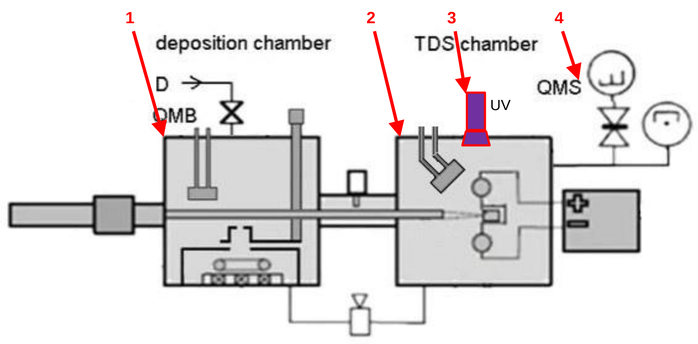


Spectra of UV radiation scattered by LiD at different moments of time

- Changes by UV exposure confirmed
- Time of full transformation ~ 5 min
- No color reversion after many days

3. UV radiation interaction with co-deposited LiD layers

3.1 Description of experiments



1. Deposition chamber
2. TDS chamber
3. UV lamp $\lambda = 180$ nm
4. Quadrupole mass spectrometer

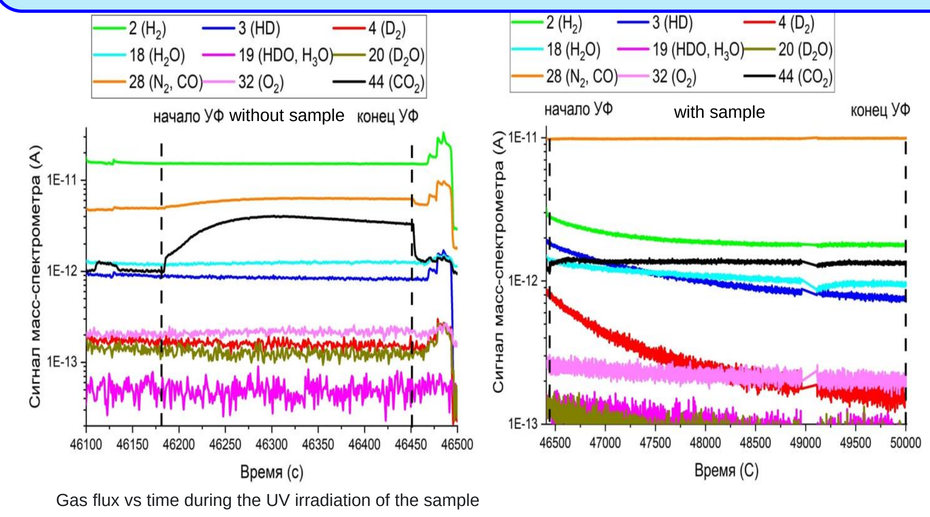
Experiment procedure:
1. Magnetron sputtering Li-D (D_2 plasma, Li CPS cathode)
2. In-vacuo transportation of the sample to the TDS chamber
3. UV irradiation 1 hour >> 5 minutes .
4. TDS 2 K/S up to 1300 K;

Gas composition control during UV irradiation.
Controlling the evaporation rate of the Li-D layer during TDS [3-5]

Installation parameters:
$\boldsymbol{P_{TDS} = 10^{-8}\ mbar}$
$P_{dep} = 3 * 10^{-7} mbar$
$P_{dep\ working} = 4 * 10^{-2}\ mbar$
Deposition rate- $3 * 10^{-8}\ g/sm^2$.
Film thickness ~ 100-500 nm
Substrate temperature ~ 293-353 K

4. Experimental results and discussion

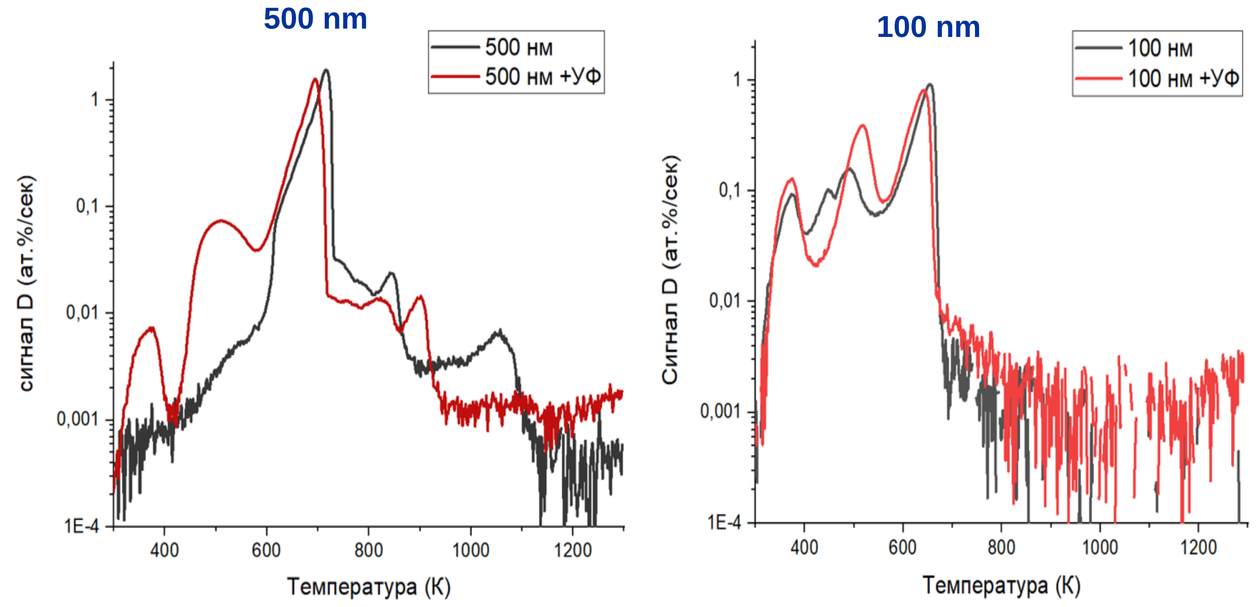
4.2 UV irradiation at room



Gas flux vs time during the UV irradiation of the sample

Gas flux was measured during UV irradiation of the sample
- No D_2 release!
- Organic matter on the walls of the chamber decomposes under UV radiation

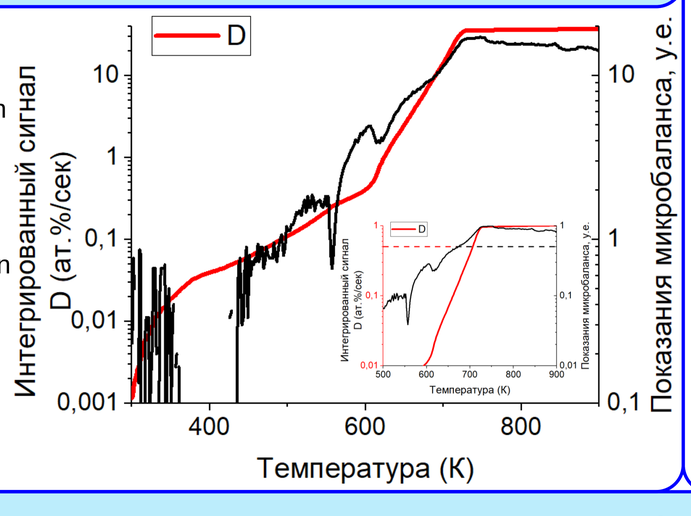
4.1 TDS analysis



- Deuterium concentration in the films ~ **30 at.%.**
- UV irradiation doesn't reduce the D content if the films
- **Additional desorption peaks** appear **after UV irradiation** at T ~ 500 K
- **High-temperature desorption peaks** disappear or shift to lower temperatures **after UV irradiation**
- The main peak corresponding to the decomposition of lithium deuteride (T ~ 700 K) is retained

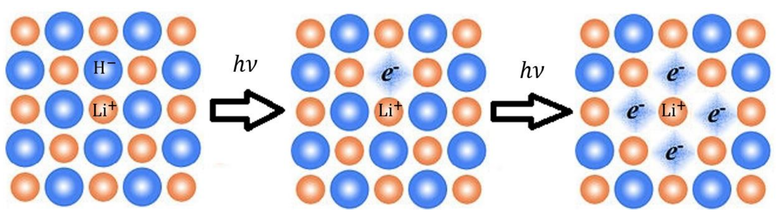
4.3 Испарение Li-D во время ТДС

The evaporation of lithium begins much earlier then the beginning of the intense release the deuterium from the sample.
The process if associated with dynamo balance of concentrations of Li, D and LiD in the sample.
Lithium evaporates and those content decreases in the sample => lithium deuteride decomposes to maintain the required lithium level in the sample.



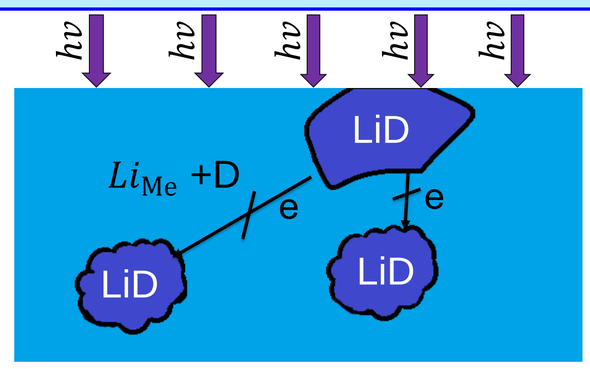
4.4. Description (model)

What does happen to crystalline hydride under UV irradiation?



Electronic defects are formed under UV irradiation [1-2]:
- bond between Li and D ions is broken
- D_2 is formed and shifts to the interstitial space
- Received vacancies are filled by electrons
- The accumulation of defects around one Li atom leads to the formation of metallic lithium with a crystal lattice

The obtained samples are metallic lithium with dissolved deuterium and with inclusions of the deuteride phase.
Only surface and close to the surface crystallites are subject to change under the influence of UV radiation. In this case, the formation of defects doesn't occur in the bulk of the layer because electronic defects cannot diffuse through metallic lithium.



5. The main conclusions

- UV irradiation at room temperature doesn't remove D_2 from the Li-D co-deposited layers
- UV irradiation leads to D_2 desorption at low temperatures T < 700 K;
- UV irradiation suppresses D_2 desorption at high temperatures
- UV irradiation of Li-D co-deposited layer affects only near-surface part of the layer

6. References

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2. Опарин Д. В. Образование и миграция дефектов в монокристаллах гидрида лития» 1985 г.
3. Krat S.A. et al. A setup for study of co-deposited films // J. Instrum. 2020. Vol. 15, № 01. P. P01011–P01011.
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5. Krat S. et al. Isotope exchange in Li-D co-deposited layers at temperatures below 200 °C // J. Nucl. Mater. 2020. P. 152064.